Field: Agri-Business

Business Intelligence in Agriculture – A Practical Approach

Authors: Grujica VICO, Danijel MIJIC, Radomir BODIROGA

2017

Boosting Adult System Education In Agriculture - AGRI BASE

Erasmus+ K2 Action Strategic Partnership

Table of contents

1. Introduction

Timely access to information is one of the important factors for successful management and decision-making in any kind of organization. The amount of data that need to be processed in order to get useful information is significantly increased due to a more intensive use of information and communication technologies (ICT) in today's society and the growing number of data sources. For this reason, it is necessary to use appropriate tools for effective data analysis and getting timely information that could help management to make informed decisions, both at the operational and at the strategic level.

Agriculture is an area with increased use of ICT, as shown by number of research papers and projects in the world (Moskvins et al., 2008; Sorensen and Bochtis, 2010; Tejas and Kalpesh, 2015; Ilie and Gheroghe, 2016, Krintz et al. 2016). The need for technologies and tools for advanced data analysis and knowledge discovery from large amounts of data becomes more evident with the increased use of intelligent and relatively inexpensive devices and sensors that can provide almost constant collection and storage of the "raw" data from the field, as well as data on the state of land, crops, or meteorological conditions (Celarc and Gros, 2013; Waga i Rabah, 2014; Garg and Aggarwal, 2016). Business intelligence could be used as an adequate solution for data analysis and providing necessary information to decision-makers at various levels. The use of business intelligence tools creates conditions for efficient management and planning by helping to analyse the facts, understand the current situation and even predict some future trends in business organization, which can have a positive impact on business results.

The aim of this course is to provide insight into possibilities of use of modern business intelligence tools in agriculture. The course provides short theoretical background on business intelligence, information about available software platforms and tools, short review of use of business intelligence in agriculture, and some practical examples of using Microsoft Excel Self-Service Business Intelligence tools.

2. Business Intelligence

2.1. Business Intelligence Overview

Business intelligence represents a set of methods and procedures intended to support the process of data analysis and decision-making based on the data. The term business intelligence was first introduced by IBM researcher Hans Peter Luhn in the article in 1958, in which the term is defined as "the ability to understand the interconnections of the presented facts in a way that leads to the achievement of the desired goal." At the end of the eighties Howard Dresner has proposed the term business intelligence whose meaning is related to "concepts and methods to improve the process of decision-making based on facts". More intensive research related to the development and implementation of business intelligence began in the late nineties. Stronger development of information and communication technologies have created the conditions for collecting, storing, processing and analyzing large amounts of data in real time, which greatly facilitate business decision-making, no longer based only on intuition of managers, rather than based on concrete information from business processes. Business intelligence development continued intensively during the last two decades and has found application in many areas of human life and work.

Today, business intelligence could be considered as a set of tools and methodologies for the use of data from the data warehouse and converting them into information for making informed business decisions. Business intelligence typically includes the following elements:

- extraction, transformation and loading of data (ETL process),
- data warehousing,
- data synthesis and analysis,
- presentation and visualization of data.

2.2. Components of a Business Intelligence System

Within a typical business intelligence system data is collected from various sources, such as databases of information systems or their individual modules and files of different form. The data is then cleaned, filtered, transformed into an appropriate form and stored in the data warehouse. Fig. 1 displays structure of a typical business intelligence system.

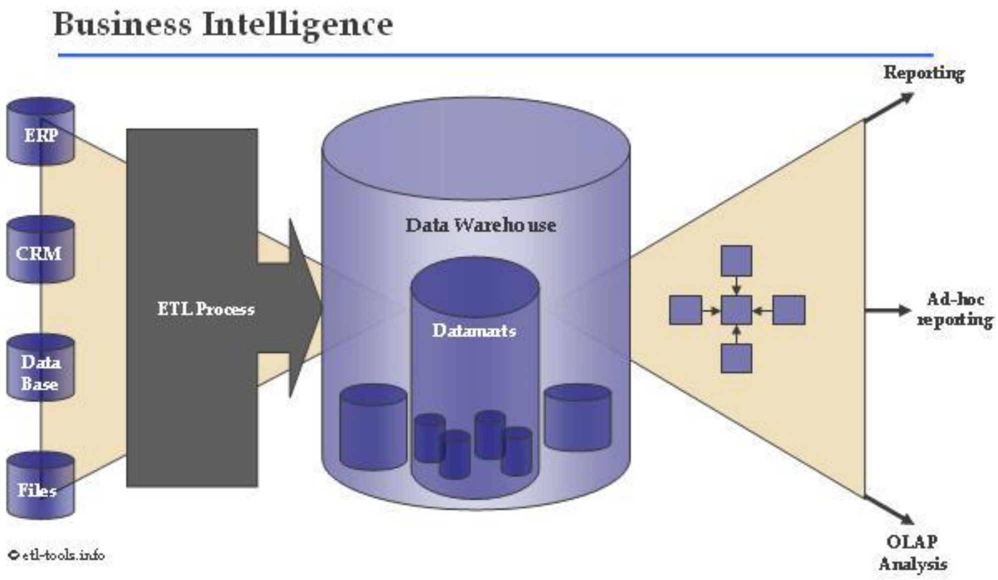


Figure 1: Structure of a business intelligence system (source: etl-tools.info)

Data warehousing refers to the storing of data in a special database whose structure is adapted to the specific needs of data analysis and reporting. In accordance with the methodology of designing a data warehouse, data warehouse usually contains more collections of data from different business units or domains, which are used for analysis and reporting. For example, one collection of data could be related to human resources of the small farm, while the other could be related to the financial information of the farm.

After loading the data into date warehouse, the data are processed and stored in a special form suitable for fast generation of reports based on different criteria. Data is stored in the form of multidimensional databases called OLAP cubes (OLAP - Online Analytical Processing), which represents a collection of numerical data

(measures), whose display can be presented in different ways, using different "dimensions" or criteria. While viewing data from OLAP cubes, the user can interactively change the display mode, the level of detail in the data and to perform analysis of data for individual dimensions by performing operations such as slice and dice, pivot, drill-up and drill- down. Slice and dice represents selecting of the desired subset of data from OLAP cubes by observation of one or more dimensions. Pivot (rotation) is the ability to change the way of presenting data to the desired display mode and the appropriate view of the data by positioning desired data on rows and columns. Drill-up and drill-down operations are used for changing levels of detail in the data from OLAP cubes, or changing levels of aggregation of numerical data from the highest level of aggregation (summary data) to the lower levels of aggregation (more detailed information).

Access to data from OLAP cubes is available by using special applications called OLAP clients. OLAP client can be any application that has the ability to access and present data from OLAP cubes. All applications of this type use a special query language to access data in OLAP cubes. By using OLAP client user can perform data analysis according to various criteria (dimensions) that are arbitrarily chosen from a set of available criteria, without requiring the user to know the details of any query language. The data are usually presented in tabular and graphical form. The advantage of a system based on using OLAP technology is that users using the appropriate OLAP clients can create reports having the desired structure and the desired level of detail by simply selecting available measures and dimensions. In other words, users are not required to have advanced IT skills to access data, basic IT literacy is usually sufficient. Most OLAP clients have a simple user interface through which users can quickly and easily create reports tailored to their needs.

2.3. Dimensional Modelling

The methodology of designing a database intended for the storage of data within the business intelligence system is based on the dimensional model. Dimensional model recognizes two basic types of entities in designing a data warehouse: facts and dimensions. Facts are events or phenomena that could be measured or observed in the business process. Dimensions are qualitative data related directly or indirectly to the facts and describing them further.

Facts are stored in a separate table called the fact table. For each event or occurrence, a fact table contains one single record with numerical data describing a given event. For example, in the field of agriculture, individual records in the fact table could have data on the work performed by machines. As numerical data that describes the facts in this case we could use number of working hours of machine. Numerical data contained in the fact tables are called measures.

Dimensions are stored in the dimensional tables that are associated with the fact table. Dimensions represent the data that in some way describes the facts. For the above example with agricultural data, the potential dimensions could be the data about the machine, the date of the operation, the operator, the type of operation and the location on which the operation is performed, and so on. Multidimensional database that could store this kind of information is displayed in Fig. 2.

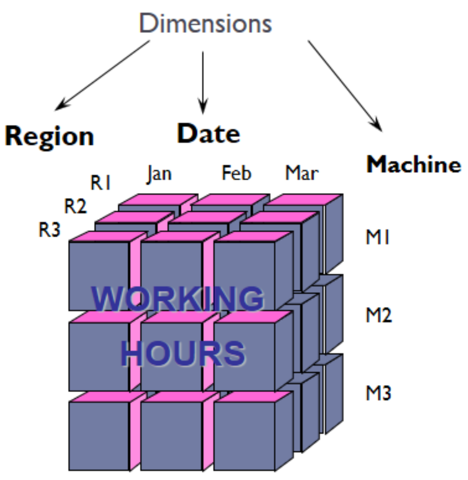


Figure 2: An example of OLAP cube

During the analysis of the data, the facts are summarized and displayed in different ways in order to get useful information for making the right business decisions. Dimensions allow for the observation and analysis of facts from different perspectives and using different levels of aggregation. For the analysis of data on the operation of agricultural machinery various criteria can be used, which are presented in the appropriate dimensions. For example, at farm level we could analyze summary data on the total number of working hours of all machines on all locations, without taking into account any dimension. If we need to analyze data at the level of specific location, machine operators, type of operation or any other dimension or their combinations, it is necessary to perform the aggregation of facts at the desired level, and to group the facts according to dimensions. By introducing extra dimensions into analysis, we increase the level of detail in the data, which results in a more detailed analysis and display of the data.

Another example is more general and enables analysis of data about product sales across different regions during the fiscal year. As a numerical measure of the sales, the quantity of the sold products could be used. Additionaly, the sale price could also be used. For dimensions related to sales, we could use product itself, region and date of sale. Fig. 3 shows two-dimensional data structure for sales across regions. Numerical measures for selected product and region are stored at the cross-section of the two dimensions. Total sales for a product or region are available as u sum of values across appropriate rows (for products) or columns (for regions).

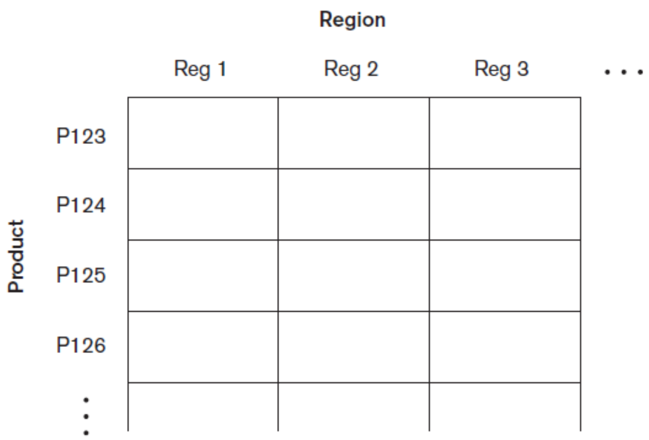


Figure 3: Two-dimensional data on product sales

If we introduce another dimension, then we have multi-dimensional database with numerical measures at cross-sections of the used dimensions. This situation is shown in Fig. 4 for three dimensions related to product sales. The data analysis could be performed using all three dimensions or less. When all dimensions are used, we get the most detailed data (at cross-sections of dimensions). If we remove some of the dimensions (e.g. region), then we get data summarized for that dimension (sales for products per fiscal quarters, for all regions). Removing all dimensions from analysis gives total sales for all products, quarters and regions.

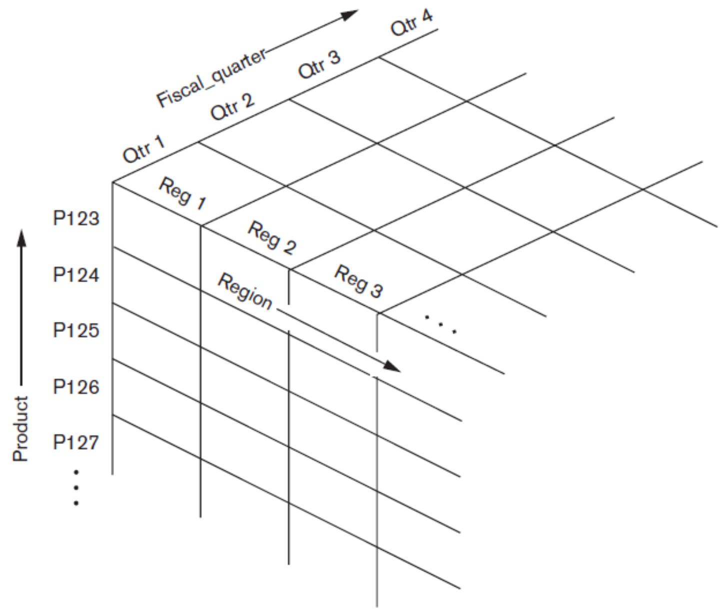


Figure 4: Three-dimensional data on product sales

3. Business Intelligence in Agriculture

There are significant opportunities for the application of business intelligence in the field of agriculture, as well as in any other area where there is a need to analyze large amounts of data make business decisions based on that data. Business intelligence can contribute to increase the production potential and technical efficiency of agricultural enterprises and farms due to the effective support of management, analytical and planning activities (Tyrychtr et al., 2015). Business intelligence and decision support systems in agriculture are used in various segments such as analysis and forecasting of prices of agricultural products on the market (Tejas and Kalpesh, 2015), determining the required level of moisture in the soil for certain crops and locations based on data on land, crops and meteorological conditions (Celarc and Gros, 2013), analysis of data on customers and competitors, analysis of meteorological and climate conditions combined with local data on farms (Krintz et al., 2016).

Some researchers introduce the concept of "agricultural intelligence," which is a combination of business intelligence and other types of information systems that are used in agriculture. Agricultural intelligence in this context does not represent a specific product or system, it is rather a specific architecture consisting of integrated operational and management components, technologies and databases that allow the agricultural community access to knowledge in the field of agriculture (Ghadiyali et al., 2011). Some of the objectives of agricultural intelligence are support in making decisions based on real data, increase of performance through the integration of business processes on farms, as well as better management of data on customers and competition.

However, the application of tools and methodologies of business intelligence, as well as other specialized business information systems in the field of agriculture, is still not satisfactory when it comes to small agricultural producers and farms, although there is a great potential. Based on the research status of business intelligence and use of specialized information systems small Czech farms, the

results show that the level of application of these technologies is at a low level, regardless of the type of production, structure and the size of the farm (Tyrychtr et al., 2015) . One reason for this situation is that these technologies and systems are still inaccessible to small producers because of high prices, but also other factors such as security, privacy and data protection. For these reasons, there are some efforts to develop systems that will be more accessible and which will solve some of these problems (Krintz et al., 2016).

In addition to the application of business intelligence it is important to mention the potential that exists in the context of decision support with current technologies such as Big Data, Internet of Things (IoT) and Cloud Computing. The term Big Data refers to a new generation of technology that allows the extraction of knowledge from large amounts of data that come from different segments of the business organization. These systems, thanks to the appropriate technologies and architectures, could provide almost continuous collection of data from a number of sources, typically using a large number of intelligent devices, sensors and sensor networks connected via the Internet, and store and analyze data. Given the volume of data to be stored in Big Data systems, classical architectures and computer systems do not have the capacity nor sufficient performance to handle this amount of data, so alternative solutions are used such as Cloud Computing. Cloud Computing provides computing resources which are sufficient to accommodate and process large amounts of data, which allows the use of analytical tools to analyze data in real time and obtain useful information for decision making. Some of the many possible applications of these systems have been tracking climate conditions (Rabah & Waga, 2014), the level of moisture in the soil, use and absorption of pesticides and fertilizers, and propose solutions for preventing diseases in crops based on analysis of historical data on crops (Garg and Aggarwal, 2016).

4. Business Intelligence Tools

4.1. Business Intelligence Platforms

Business intelligence plaftorms are set of software tools that enable building of business intelligence systems. Typical components of the platform enable extraction, transformation and loading of data, data warehosing, analysis and reporting. These functional modules are basicly the main building blocks of a business intelligence system.

There are many BI platforms available on the marker. Some of them are commercial, while other are available for free. As usually, commercial versions are more powerful then their free counterparts. Some of the mostly used commercial BI platforms are the following:

- IBM (IBM Cognos Business Intelligence)
- Oracle (Oracle Business Intelligence Enterprise Edition)
- MicroStrategy (MicroStrategy Analytics Platform)
- Microsoft (Microsoft SQL Server BI Platform)
- SAP (BusinessObjects BI Platform)
- SAS

Some of the free open-source BI platforms are the following:

- Pentaho
- SpagoBI
- Jaspersoft
- Palo
- Eclipse BIRT

4.2. Microsoft SQL Server Business Intelligence Platform

One of the mostly used business intelligence plaforms is Microsoft SQL Server Business Intelligence Platform. It consists of the following elements:

- Microsoft SQL Server Database Engine
- Microsoft SQL Server Integration Services (SSIS)
- Microsoft SQL Server Analysis Services (SSAS)
- Microsoft SQL Server Reporting Services (SSRS)

The database engine component is standard component of Microsoft SQL Server database management system. In the context of business intelligence, it is used for creating the data warehouse relational database and for storage of the data.

SSIS component is used for extraction, transformation and loading of data into the data warehouse. SSIS enables creation of varios data packages which encapsulate set of operations on data in order to get the data from various sources, to process, clean and transform the data, and finaly to load the data into data warehouse.

SSAS component represents a module for creation, storage and use of multidimensional dababases, OLAP cubes, which are used for data analysis and reporting.

SSRS is reporting component which enables development and management of reports, automatic delivery of reports, and provides access to reports from other applications. Users are also able to access reports using web based interface.

For the development, operation, and maintenance of a business intelligence systems on this kind of business intelligence platforms, it is necessary to have very specific expert knowledge in this domain. This kind of platforms are used for central data warehousing and analysis on the level of the organization. Some of the advantages of using these platforms are the availability of information throughout the organization, central data repository for historical data and trends, removing redundant data, etc. However, there are also some donwsides, like complexity of the system development and maintenance. If some small change in the data model is needed, this change needs the involvement of IT staff and a significant amount of time for the change to be implemented and usable in the system. In come cases, this is not convenient for business users who want to take advantage

of new data sources, or to slightly modify existing behaviour of data. For addressing this issue, there are some alternative tools that could be used in order to provide more flexibility.

4.3. Microsoft Self-Service Business Intelligence Tools

Self-Service Business Intelligence is a term that represents creation and use of simple business intelligence systems without the need for engaging IT experts that are typically involved in design and implementation of complex business intelligence systems. This doesn't mean that this is the replacement of classical business intelligence systems, but rather its supplement that can help business users to explore various sources of data and perform custom data analysis on individual basis and using their own knowledge and understanding of the required tools. In this sense it is a self-service solution that doesn't rely on external expertize. By using available tools, users can supplement existing business intelligence solution by extending its potential to additional data sources, custom measures and dimensions, and creating customized reports and views on the data.
Having this in mind, Microsoft corporation has developed additional set of tools for this purpose, besides the existing Microsoft SQL Server business intelligence platform. The central point in this set of tools is Power Pivot. Other tools are also available and could be used with Power Pivot. These tools are Power View, Power Query and Power Map. They will be briefly described in the next sections.

4.3.1. Power Pivot

Power Pivot functions an an add-in to Microsoft Excel. It is available for Excel versions of 2013 and newer. The main features of Power Pivot are easy integration of data from large number of different sources, handling large amounts of data (up to hundreds of millions of rows) and uses familiar Excel interface with data analysis functions such as pivot tables and pivot charts. Additionaly, there is a powerful language for creating expressions, called Data Analysis Expressions

(DAX). Power Pivot serves as a powerful engine for data analysis and as a repository of data for other self-service business intelligence tools.

For using Power Pivot, it should be enabled in Excel File/Options/Add-ins menu. After opening this menu in Excel 2016, a window appears with a list of active and inactive add-ins, like in Fig. 5.

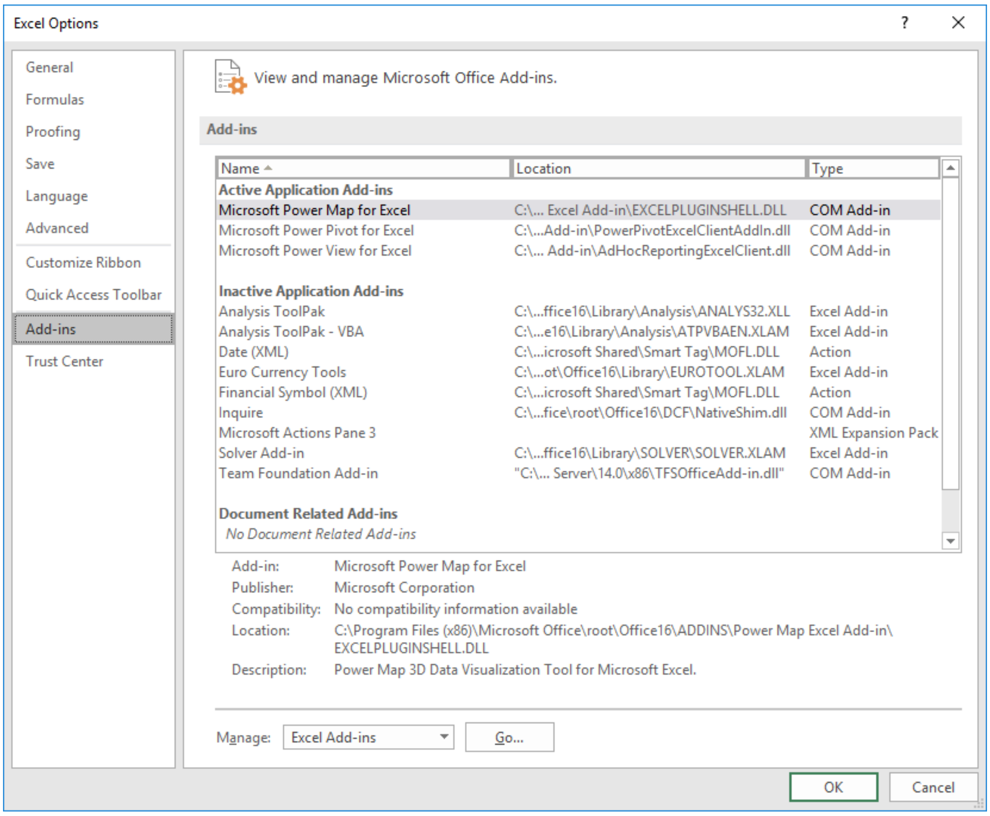


Figure 5: List of Excel add-ins

To manage add-ins, we should select appropriate option in *Manage* select list at the bottom of the windows. For Power Pivot and other self-service business intelligence add-ins, we should select *COM Add-in* option. After click on Go... button, a list of add-ins appears and we can activate or deactivate them, like it is shown in Fig. 6.

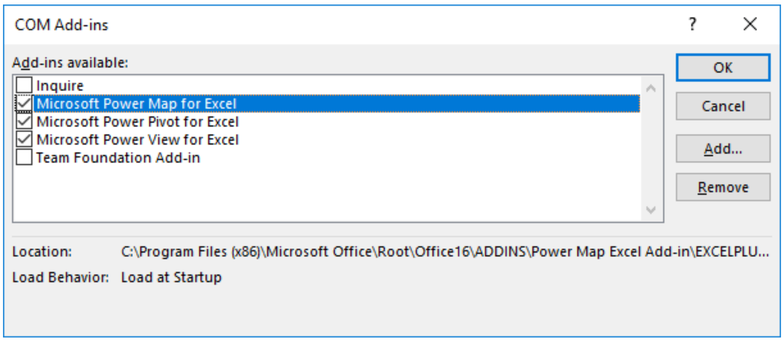


Figure 6: Manage Excel add-ins window

After activating Power Pivot add-in, a separate menu option in the main Excel windows is available. This menu option contains buttons for activating Power Pivot specific commands (Fig. 7) for managing the data model, definition of measures and KPIs (Key Performance Indicators), etc.

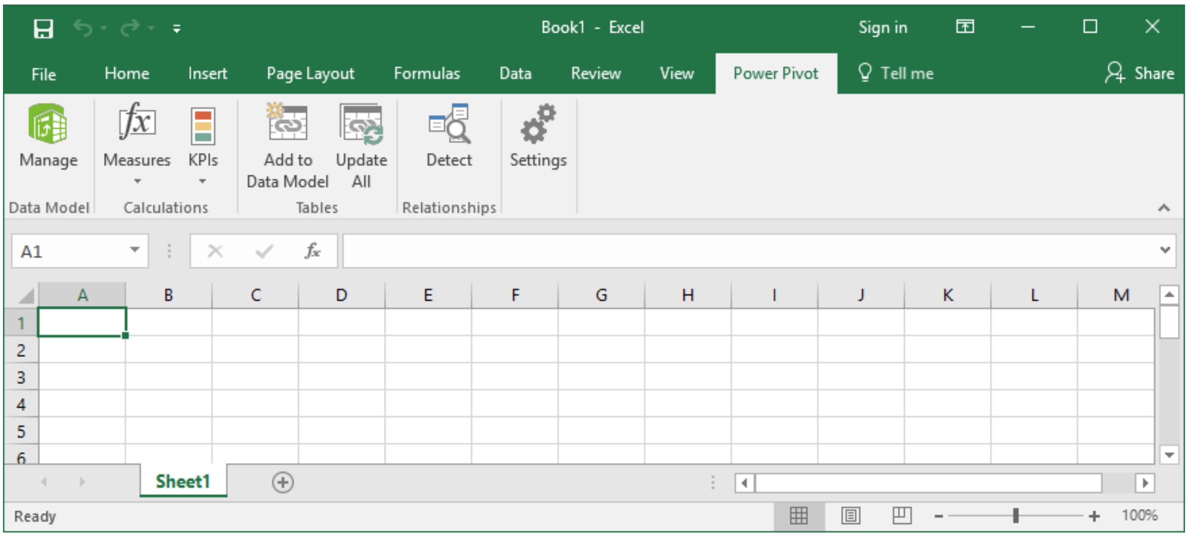


Figure 7: Power Pivot menu

4.3.2. Power View

Power View is a type of Excel worksheet that is intended for development of interactive reports and visualizations with possibility for ad-hoc exploration of data. It uses data from Power Pivot data model. Power View is good choice for users who are not Excel experts, but who want to explore the available data and to get insights from the data. Power View features enable creation of many different

types of visualizations, such as tables and matrices, different types of line/bar charts, scatter graphs, map-based visualizations and interactive dashboards.

To create a Power View report, it is required to activate Power View add-in and select Power Pivot command from Excel Insert menu. In Excel 2016, Power View add-in is activated by default, but the command is not shown in the ribbon. To display this command in the ribbon, it is required to go to Excel Options/Customize Ribbon menu and select Power View command from the list of commands not in the ribbon. After this is done, Power View button is displayed in the ribbon (Fig. 8). For using Power View, a Power Pivot data model should be created, or a set of data in Excel worksheet should be selected prior to creating Power View report.

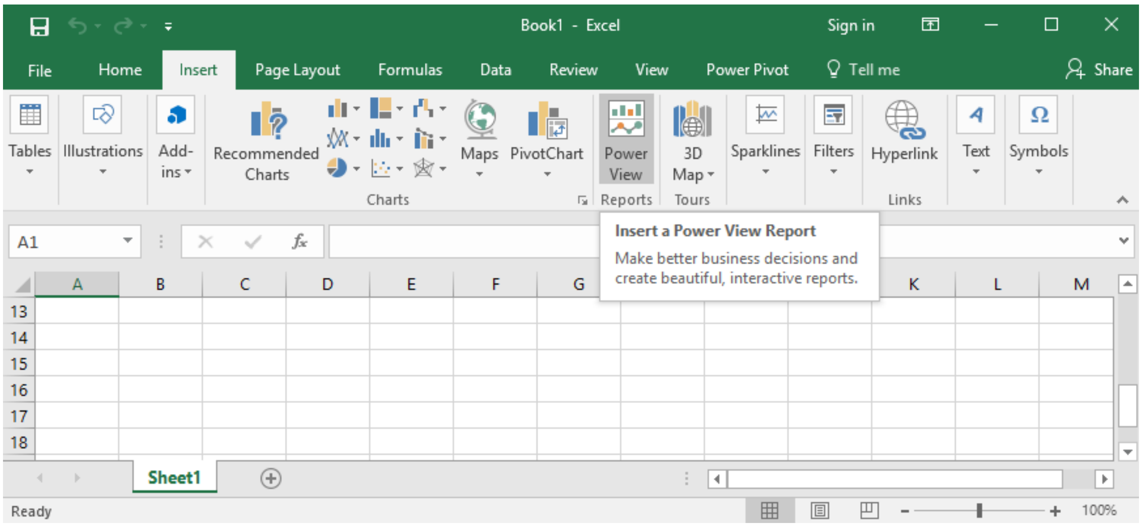


Figure 8: Insert Power View report

4.3.3. Power Query

Power Query could be considered as more simple alternative to standard tools for extraction, transformation and loading of data. It enables additional functionalities for connecting to different data sources and manipulating data before loading it into the Power Pivot data model. It is already available in Excel 2016 menu under Data menu option (Fig. 9).

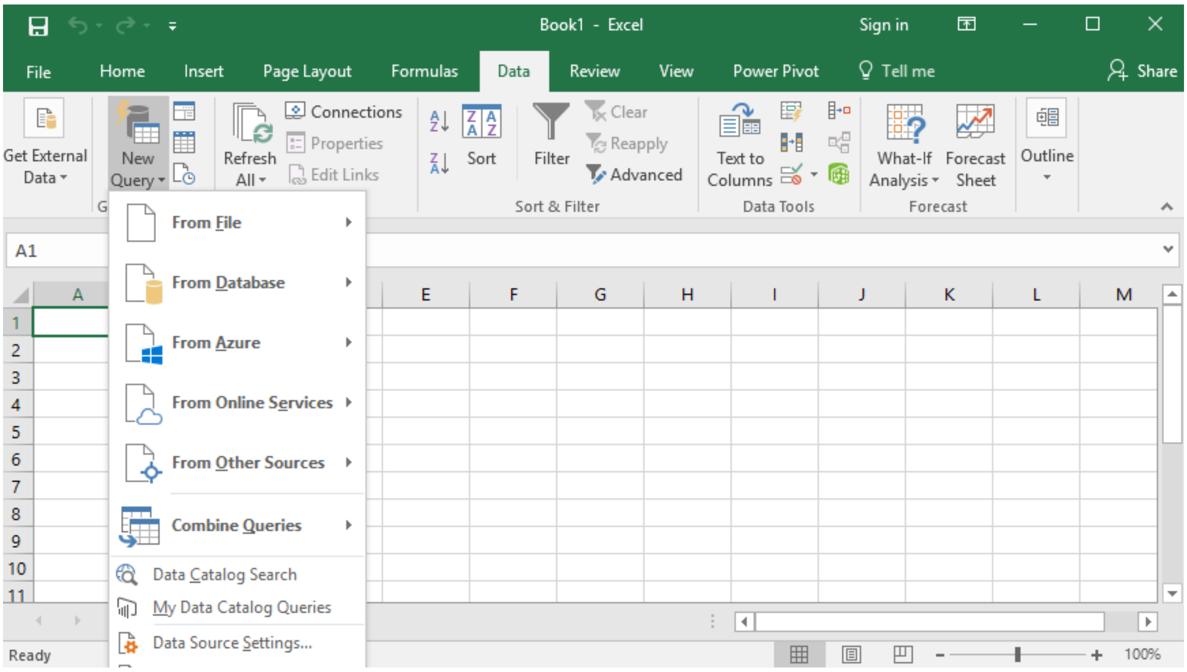


Figure 9: Power Query menu options

4.3.4. Power Map

Power Map is an element of Excel self-service platform which enables visualization of geospatial data. It could be used on large sets of data that have geocoded elements. Visualization forms include column, heat and buble maps that are positioned on top of 3D Bing map. If the data contains timestamp, it is also possible to create interactive views of data over time scale.

Power Map is also an Excel add-in which should be activated in a similar way like Power Pivot and Power View. After activation, a Power Map coud be used by selecting 3D Map option from Insert menu, like in Fig. 10.

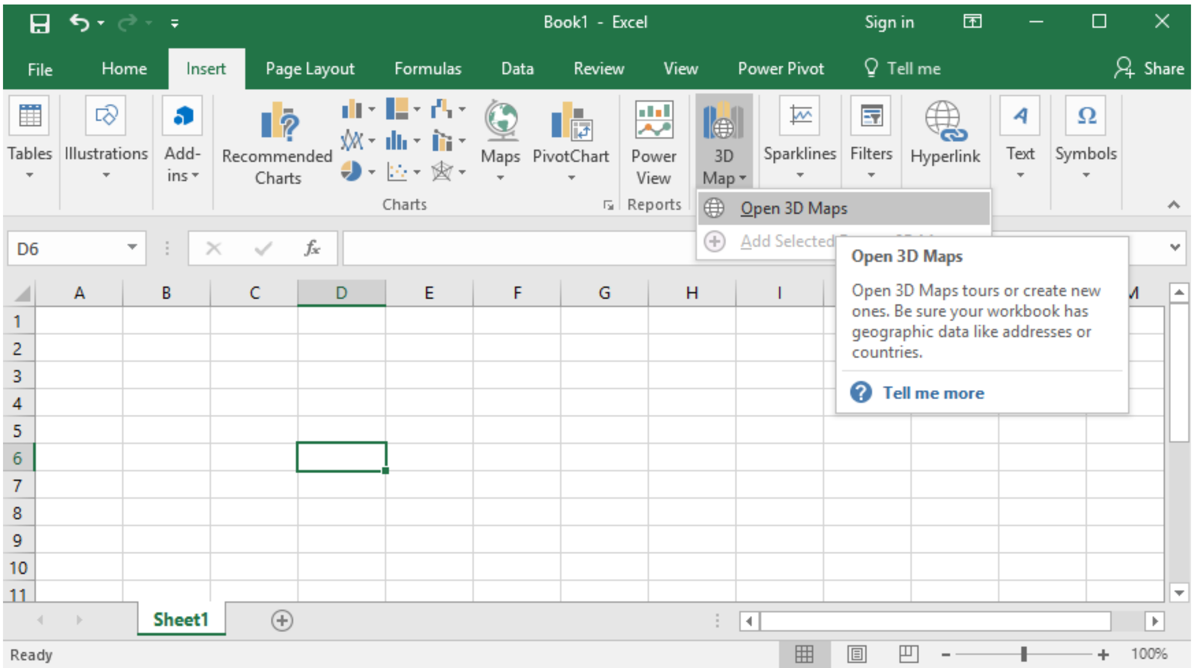


Figure 10: Power Map menu option

5. Practical Examples

In this section some practical examples will be shown to illustrate the use of self-service business intelligence tools available in Microsoft Excel. The examples are made with Excel 2016.

5.1. Average Number of Household Members per Municipality

In this example, an average number of household members per municipality will we shown using Power Pivot and Power Map tools.

After inserting pivot table in the worksheet, it is needed to select appropriate data fields for display as values and rows (Fig. 11). It is also needed to define the type of aggregation for selected values. Selected field for display on rows is *Municipality*, and for values it is *Number of household members*. This can be seen on the right hand side of the window within the PivotTable Fields list. Since we need an average value, we need to change default aggregation from Sum to Average. This is done by changing value field settings in drop down menu.

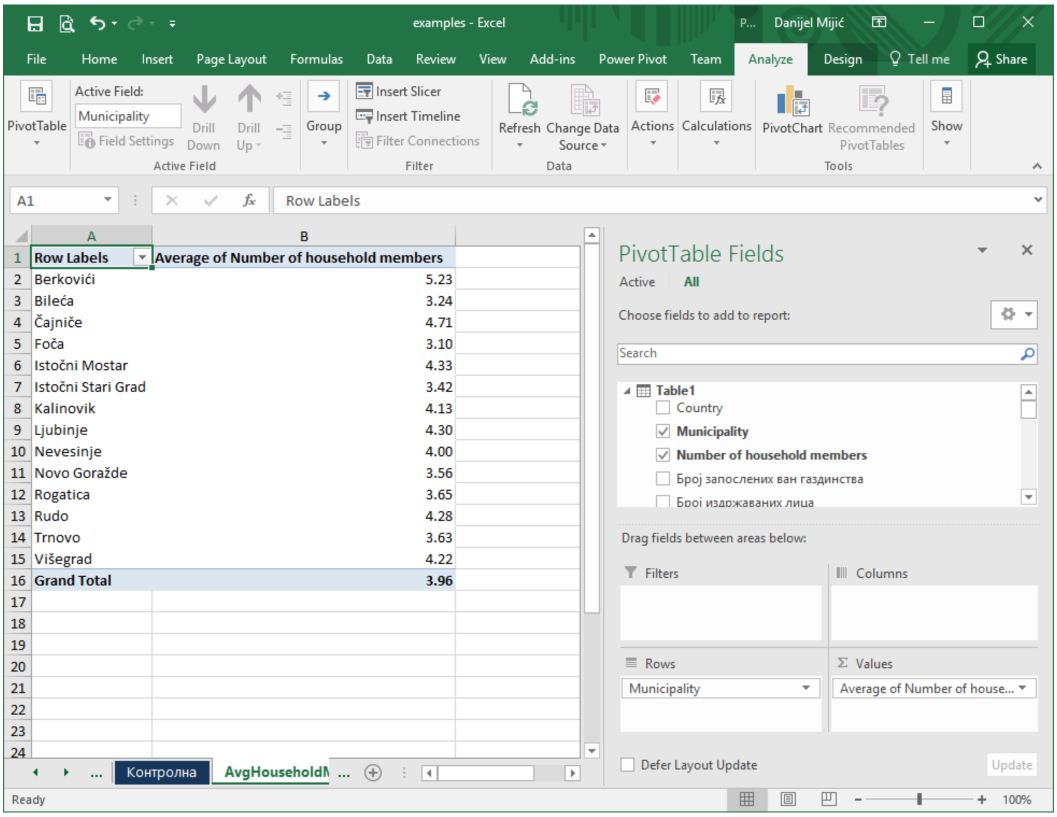


Figure 11: Display of Average Number of Household Members per Municipality

To display this data on a map, we need to create new 3D map and set appropriate data to display. For correct display on a map it is needed to select location field or fields, and than to select a fields for values to be shown on a map. Available field are displayed in the field list (Fig. 12). They could be dragged to appropriate places on the map layer settings (Location, Height, Categories).

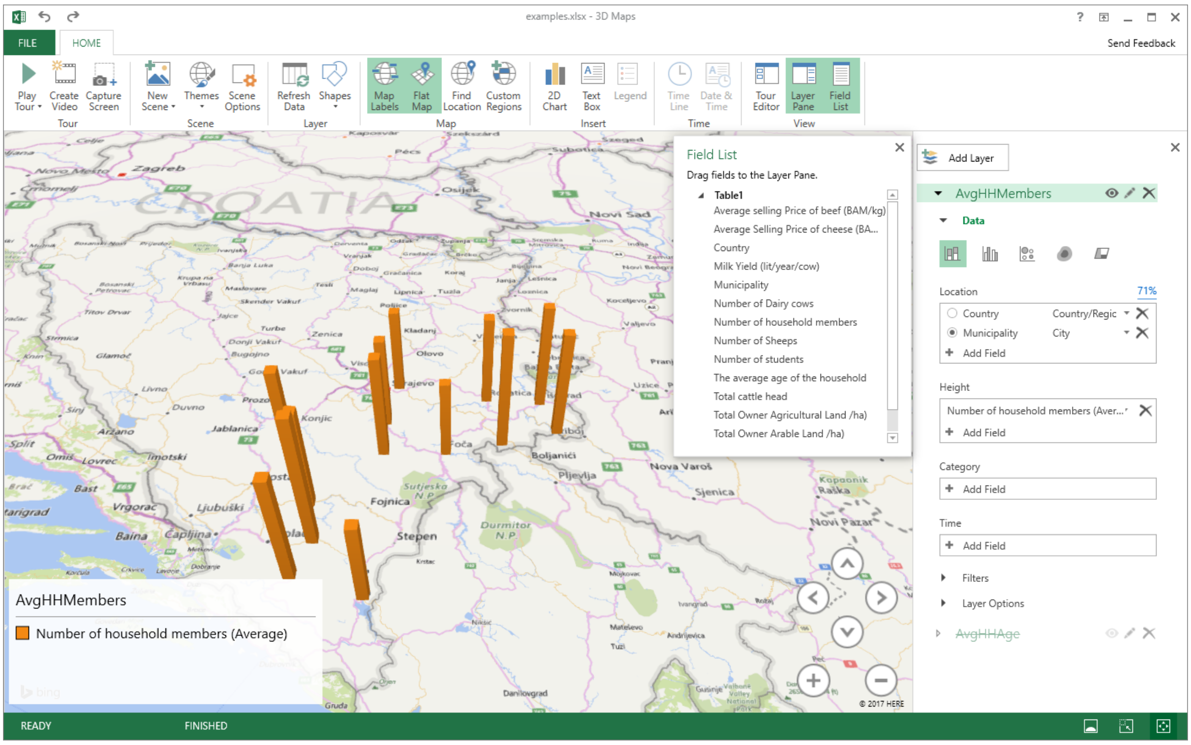
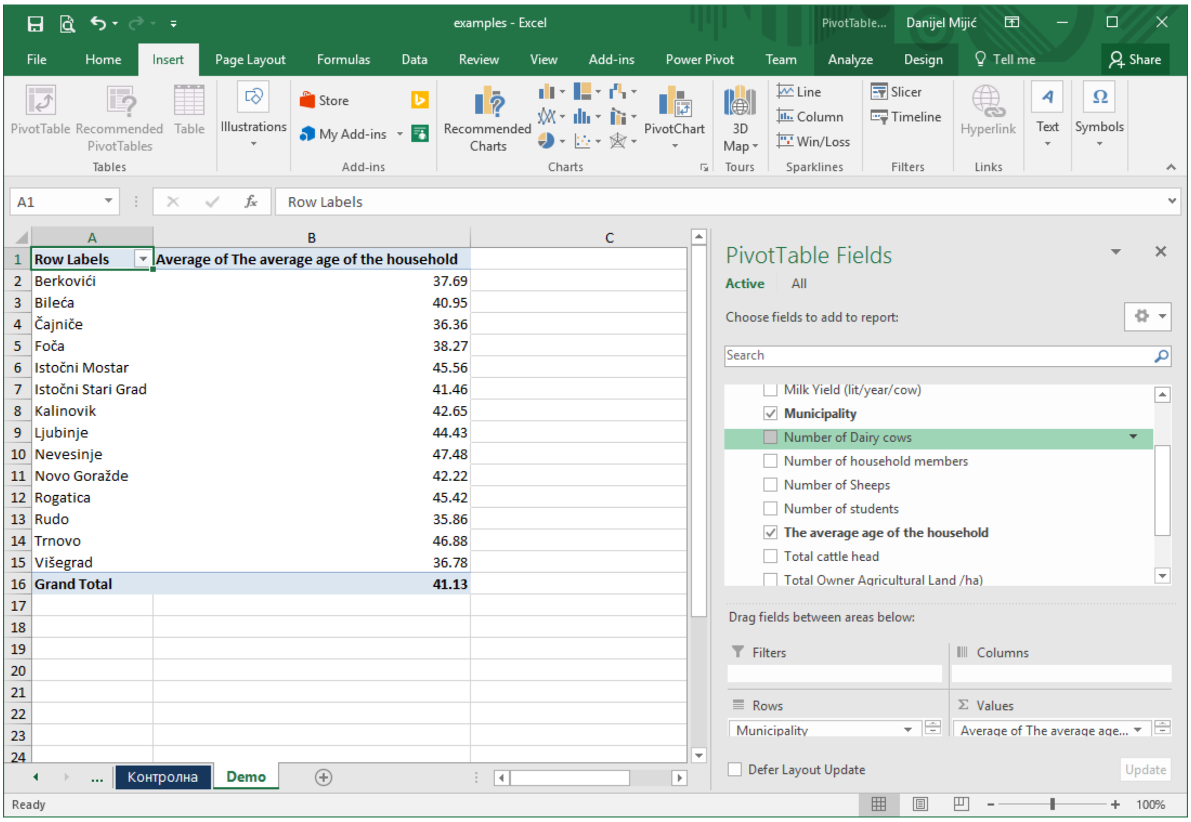


Figure 12: Average number of household members per municipality – map view

5.2. Average Age of Household Members per Municipality

This example shows average age of household members per municipality. In a similar way like in the previous example, we select appropriate data fields to display on rows and values, and if necessary, we change the aggregation type. In this case, it is also required to change aggregation to average. The data are displayed in pivot table and on a map (Fig. 13 and Fig. 14)



Row Labels	Average of The average age of the household
Berkovići	37.69
Bileća	40.95
Čajniče	36.36
Foča	38.27
Istočni Mostar	45.56
Istočni Stari Grad	41.46
Kalinovik	42.65
Ljubinje	44.43
Nevesinje	47.48
Novo Goražde	42.22
Rogatica	45.42
Rudo	35.86
Trnovo	46.88
Višegrad	36.78
Grand Total	41.13

Figure 13: Average age of household members per municipality in a pivot table

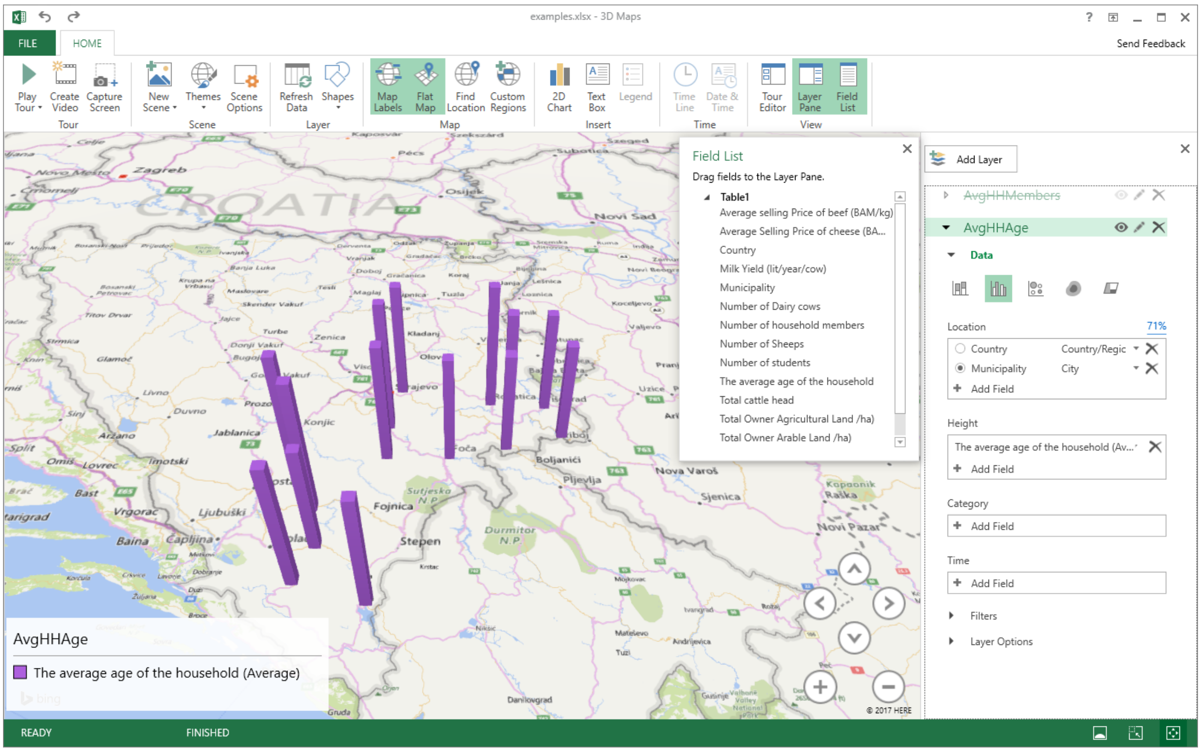
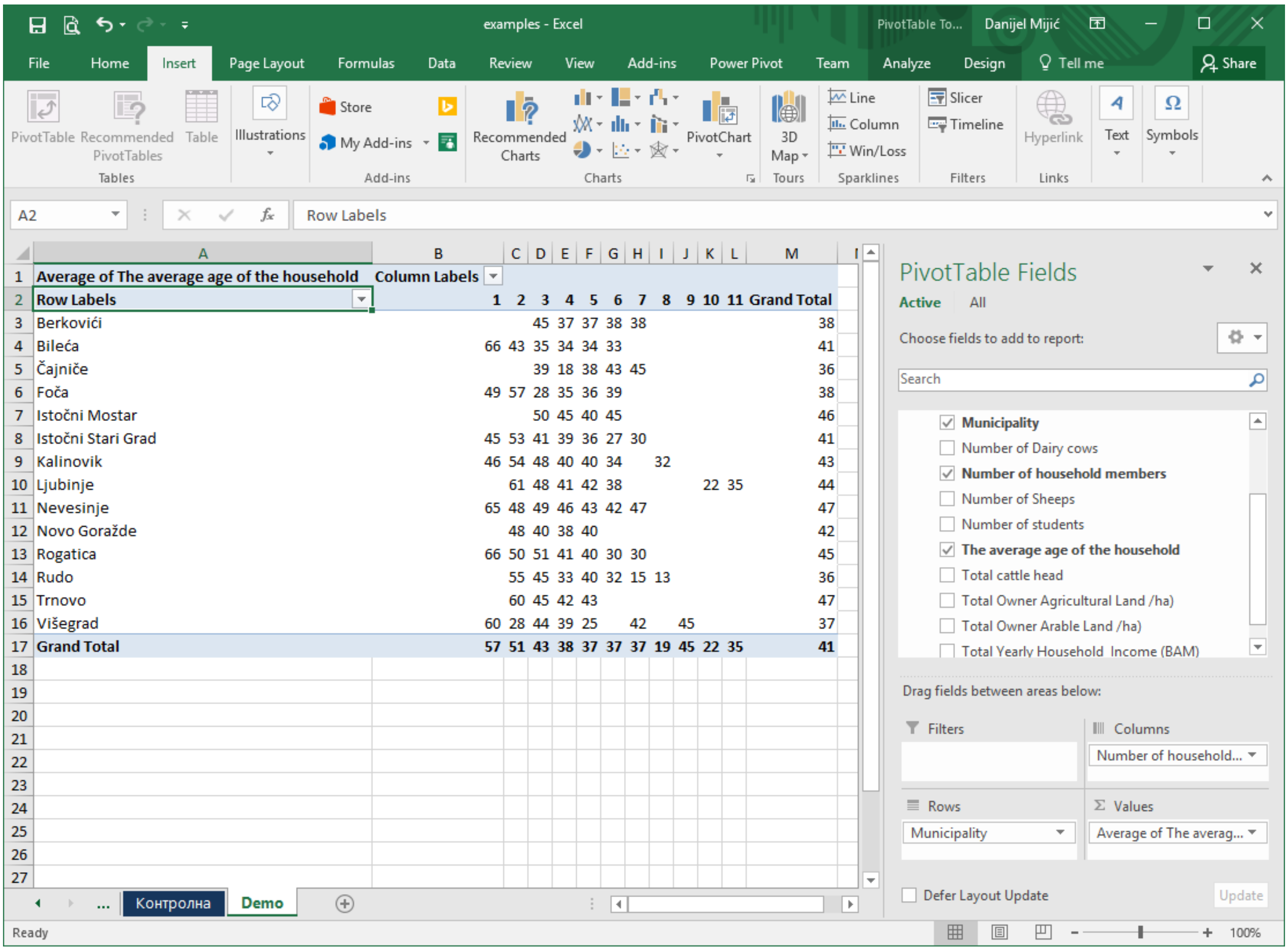


Figure 14: Average age of household members per municipality – map view

5.3. Distribution of Number of Household Members and Average Age of Household Members per Municipality

This example introduces the use of column data fields to enable views of data from different perspectives. By display of *Municipalities* on rows, *Number of household members* on columns, and *Average age of household members* as values, we can see a distribution of average age by municipalities and also by number or household members (Fig. 15). From this example it could be seen that the average age decreases with increase of household members.



Average of The average age of the household	Column Labels											
Row Labels	1	2	3	4	5	6	7	8	9	10	11	Grand Total
Berkovići			45	37	37	38	38					38
Bileća	66	43	35	34	34	33						41
Čajniče			39	18	38	43	45					36
Foča	49	57	28	35	36	39						38
Istočni Mostar			50	45	40	45						46
Istočni Stari Grad	45	53	41	39	36	27	30					41
Kalinovik	46	54	48	40	40	34		32				43
Ljubinje		61	48	41	42	38				22	35	44
Nevesinje	65	48	49	46	43	42	47					47
Novo Goražde		48	40	38	40							42
Rogatica	66	50	51	41	40	30	30					45
Rudo		55	45	33	40	32	15	13				36
Trnovo		60	45	42	43							47
Višegrad	60	28	44	39	25		42		45			37
Grand Total	57	51	43	38	37	37	37	19	45	22	35	41

Figure 15: Number of household members and average age of household members per municipality

5.4. Number of Students per Municipality

This simple example illustrates the use of default aggregation type for data field Number of students. The data is displayed as a sum of values per municipality in pivot table and also on interactive map (Fig. 16 and Fig. 17).

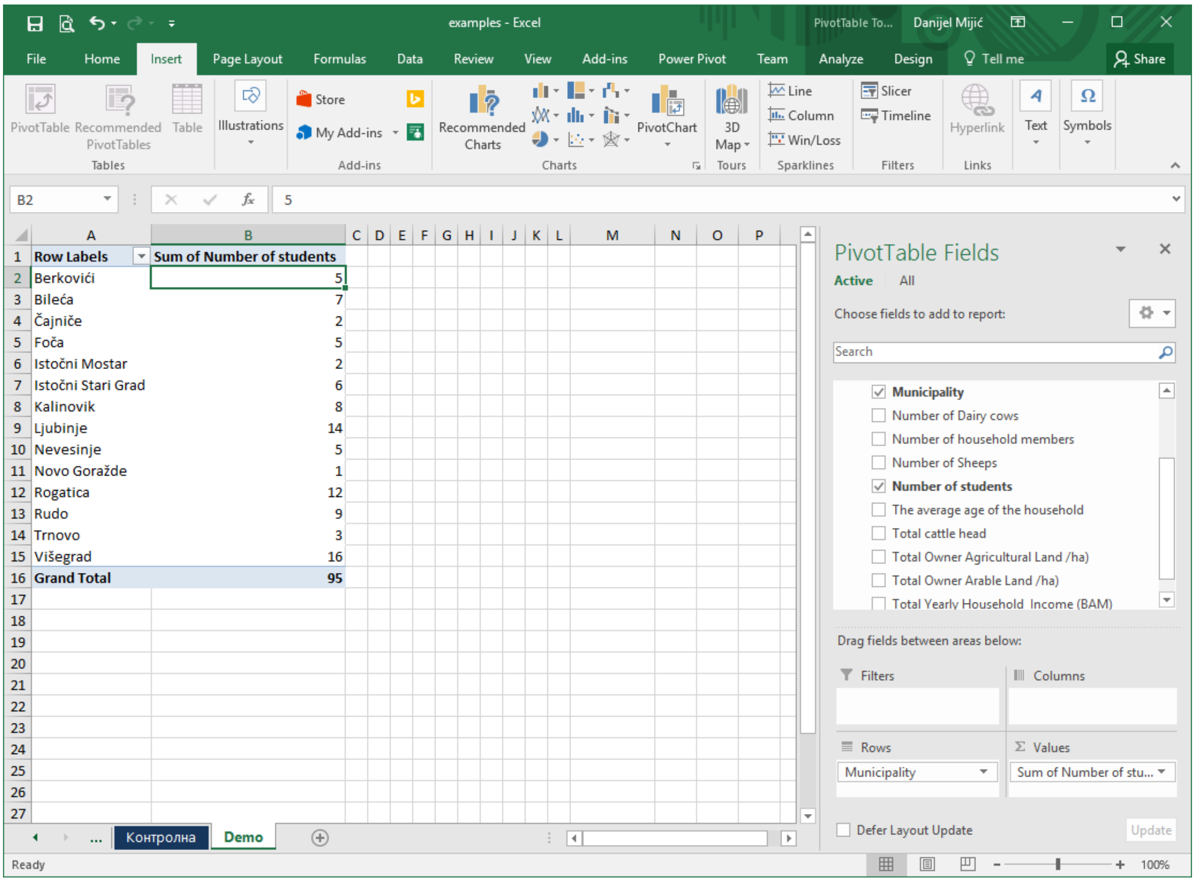


Figure 16: Number of students per municipality

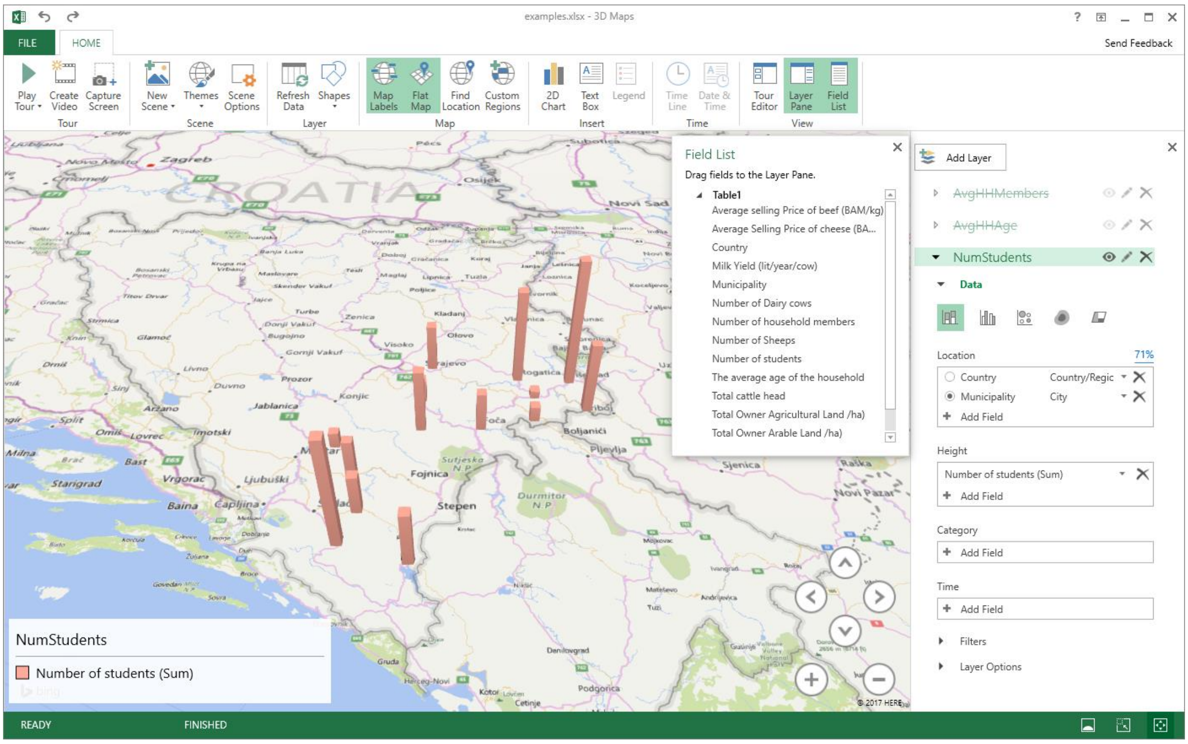
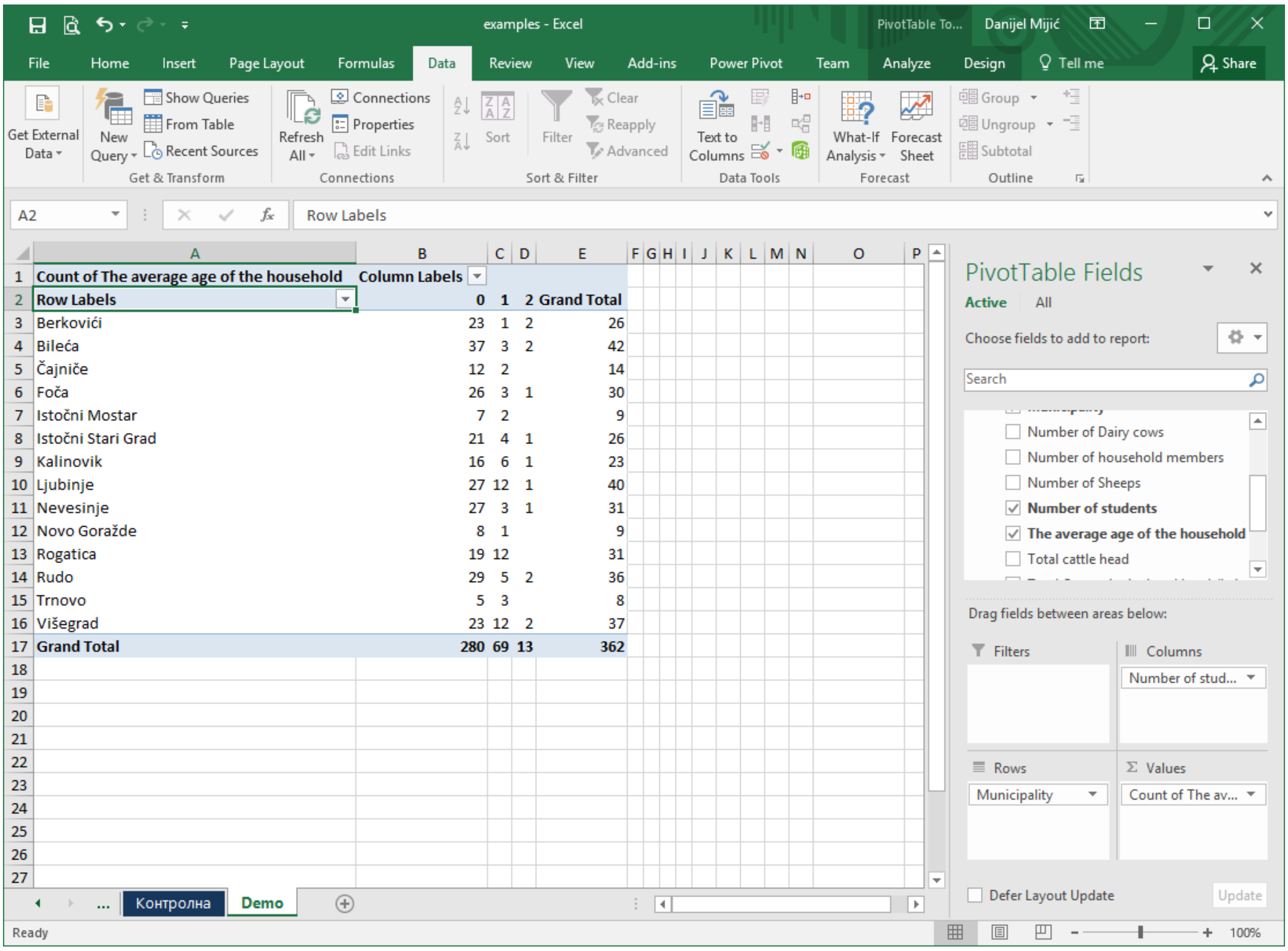


Figure 17: Number of students per municipality – map view

If we want to see the number of households by number of students, we could change the aggregation type of the value field to Count. In this way the displayed data doesn't show average age any more, but it show number of households having specific number of students, per municipalities (Fig. 18).

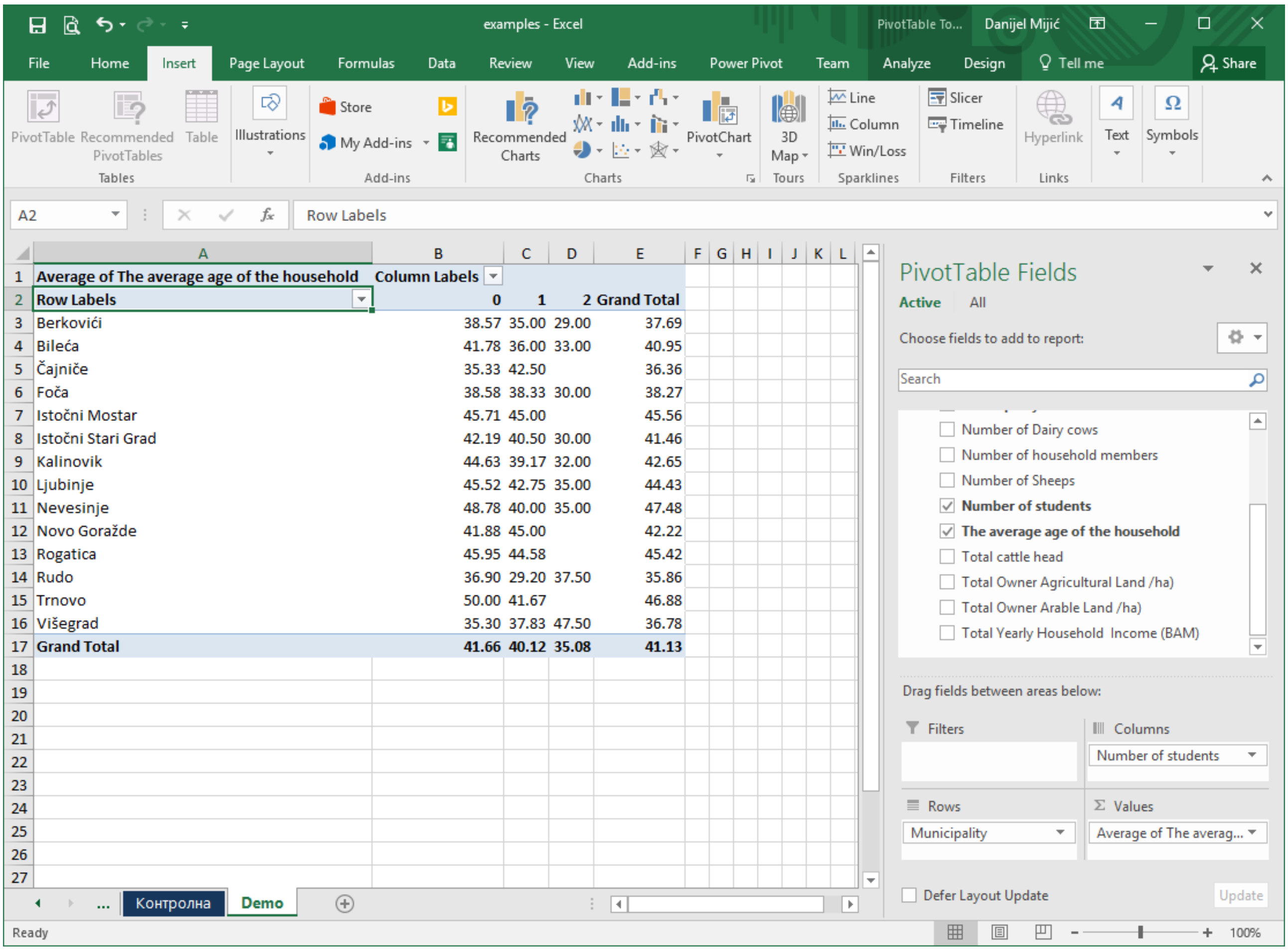


Count of The average age of the household	Column Labels			
Row Labels	0	1	2	Grand Total
Berkovići	23	1	2	26
Bileća	37	3	2	42
Čajniče	12	2		14
Foča	26	3	1	30
Istočni Mostar	7	2		9
Istočni Stari Grad	21	4	1	26
Kalinovik	16	6	1	23
Ljubinje	27	12	1	40
Nevesinje	27	3	1	31
Novo Goražde	8	1		9
Rogatica	19	12		31
Rudo	29	5	2	36
Trnovo	5	3		8
Višegrad	23	12	2	37
Grand Total	280	69	13	362

Figure 18: Number of households per number of students per municipality

5.5. Distribution of Number of Students and Average Age of Household Members per Municipality

In a similar way like display of average age of household members by number of household members, this example shows the use of different field to analyze impact of number of students on average age of household members. The data is displayed in pivot table. It could be seen that number of students ranges from zero to two on a household level, and the average age per municipality is decreasing with the increase of number of students (Fig. 19).

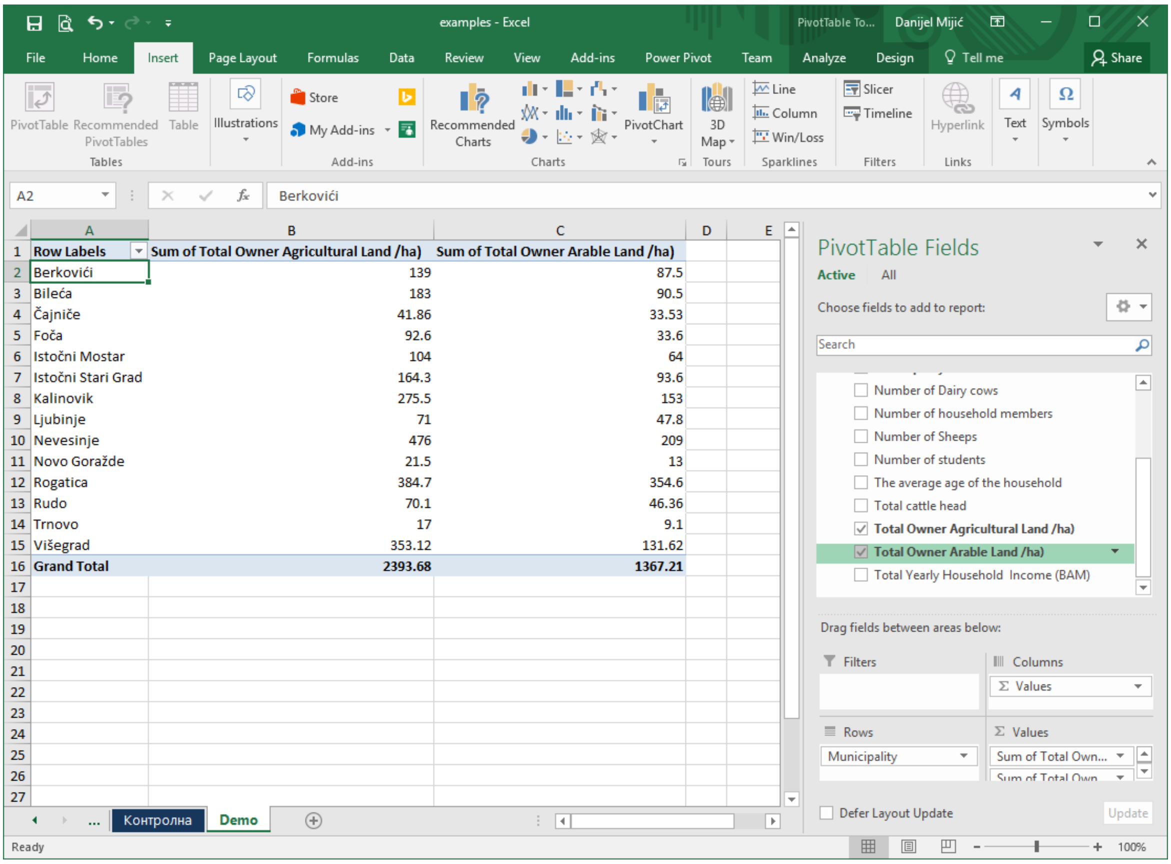


Average of The average age of the household	Column Labels			
Row Labels	0	1	2	Grand Total
Berkovići	38.57	35.00	29.00	37.69
Bileća	41.78	36.00	33.00	40.95
Čajniče	35.33	42.50		36.36
Foča	38.58	38.33	30.00	38.27
Istočni Mostar	45.71	45.00		45.56
Istočni Stari Grad	42.19	40.50	30.00	41.46
Kalinovik	44.63	39.17	32.00	42.65
Ljubinje	45.52	42.75	35.00	44.43
Nevesinje	48.78	40.00	35.00	47.48
Novo Goražde	41.88	45.00		42.22
Rogatica	45.95	44.58		45.42
Rudo	36.90	29.20	37.50	35.86
Trnovo	50.00	41.67		46.88
Višegrad	35.30	37.83	47.50	36.78
Grand Total	41.66	40.12	35.08	41.13

Figure 19: Number of students and average age of houshold per municipality

5.6. Total Agricultural Land and Total Arable Land per Municipality

This examples shows total agricultural land owned by households and total arable land owned by households. The data is displayed in pivot table and also on map (Fig. 20 and Fig. 21). Map view is using pie-chart graph to represent total amounts of land per municipalities. In this way it is easier to get information from a graphical representation of values and distribution over the map area.



Row Labels	Sum of Total Owner Agricultural Land /ha)	Sum of Total Owner Arable Land /ha)
Berkovići	139	87.5
Bileća	183	90.5
Čajniče	41.86	33.53
Foča	92.6	33.6
Istočni Mostar	104	64
Istočni Stari Grad	164.3	93.6
Kalinovik	275.5	153
Ljubinje	71	47.8
Nevesinje	476	209
Novo Goražde	21.5	13
Rogatica	384.7	354.6
Rudo	70.1	46.36
Trnovo	17	9.1
Višegrad	353.12	131.62
Grand Total	2393.68	1367.21

Figure 20: Total agricultural land and total arable land per municipality

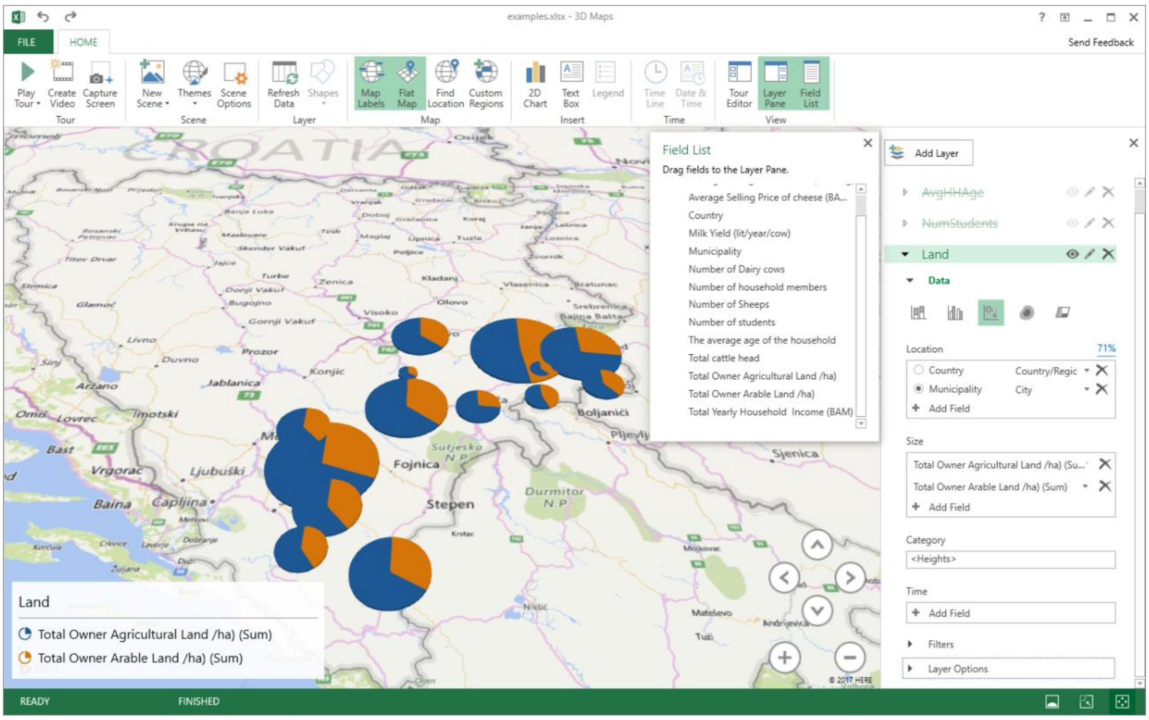
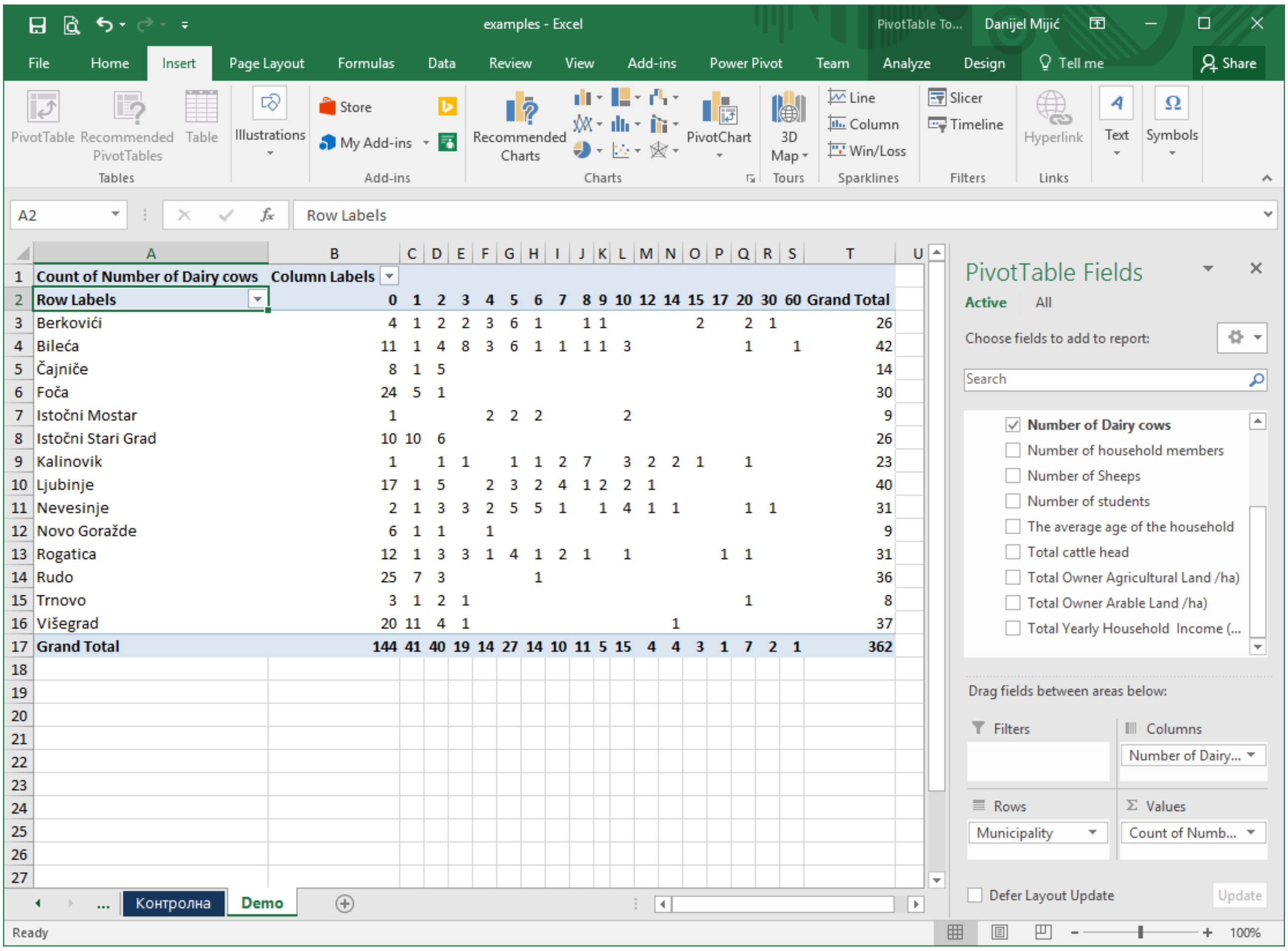


Figure 21: Total agricultural land and total arable land per municipality – map view

5.7. Distribution of Households by Number of Dairy Cows per Municipality

In this example, the number of households having specific number of dairy cows is displayed per municipality. *Number of dairy cows* data item is displayed on columns, *Municipalities* data item is displayed on rows, and *Number of dairy cows* is also used as values, but with aggregation type set to Count. In this setting, the values in the pivot table reflect the number of households having specific number of dairy cows. If a value is not present at a cross-section of specific row (Municipality) and column (Number of dairy cows) it means there are now households having that specific number of dairy cows at specific municipality (Fig. 22).

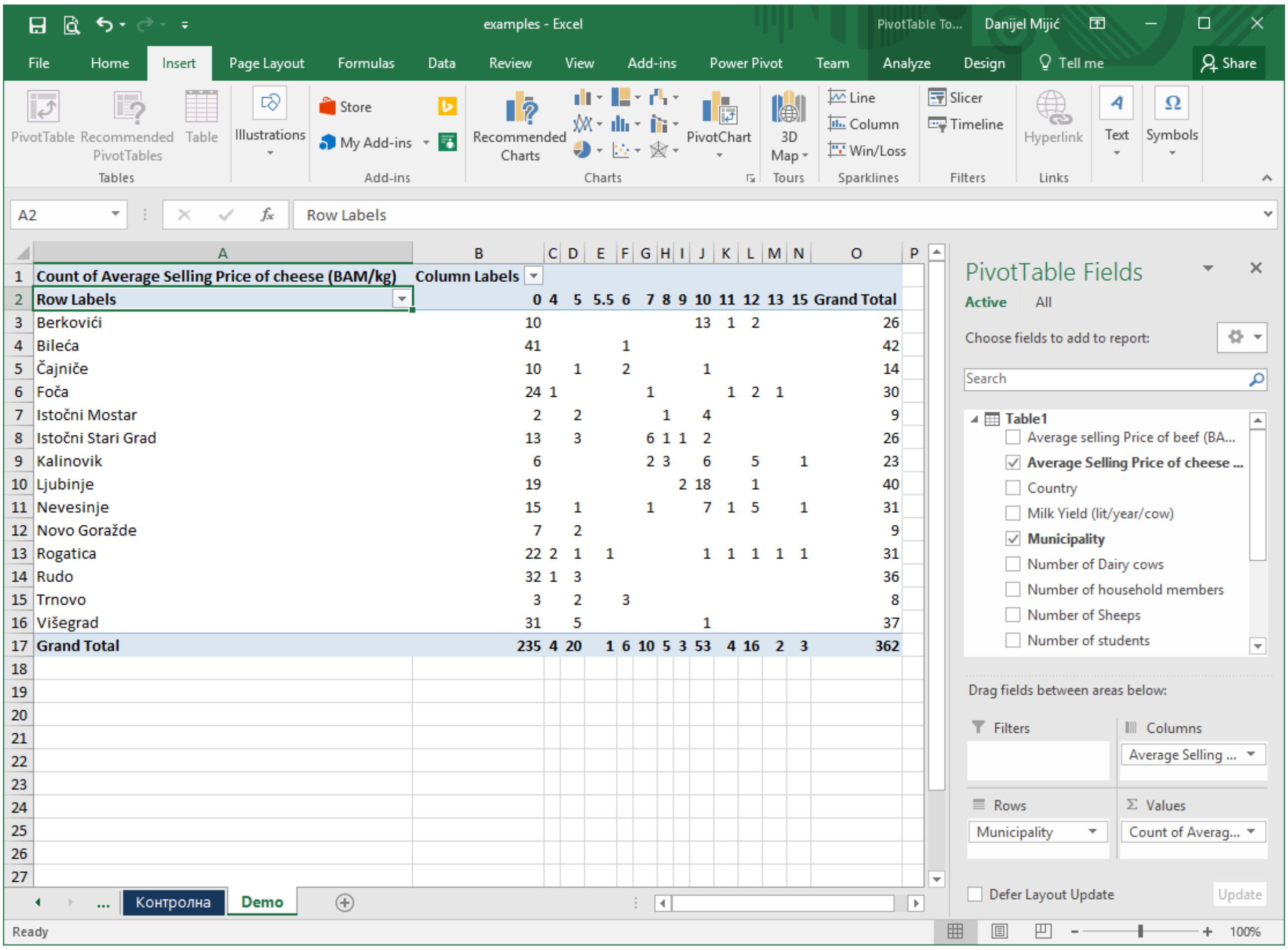


Count of Number of Dairy cows	Column Labels																		
Row Labels	0	1	2	3	4	5	6	7	8	9	10	12	14	15	17	20	30	60	Grand Total
Berkovići	4	1	2	2	3	6	1		1	1				2		2	1		26
Bileća	11	1	4	8	3	6	1	1	1	1	3					1		1	42
Čajniče	8	1	5																14
Foča	24	5	1																30
Istočni Mostar	1				2	2	2				2								9
Istočni Stari Grad	10	10	6																26
Kalinovik	1		1	1		1	1	2	7		3	2	2	1		1			23
Ljubinje	17	1	5		2	3	2	4	1	2	2	1							40
Nevesinje	2	1	3	3	2	5	5	1		1	4	1	1			1	1		31
Novo Goražde	6	1	1		1														9
Rogatica	12	1	3	3	1	4	1	2	1		1				1	1			31
Rudo	25	7	3				1												36
Trnovo	3	1	2	1												1			8
Višegrad	20	11	4	1									1						37
Grand Total	144	41	40	19	14	27	14	10	11	5	15	4	4	3	1	7	2	1	362

Figure 22: Distribution of houeholds by number of dairy cows

5.8. Distribution of Households by Average Selling Price of Cheese

This example is similar to previous, but shows different data on columns. The column data is set to *Average Selling Price of Cheese*. Values are set to Count of the same data item displayed on columns. From this view it could be concluded that large number of households do not sell cheese. The number of this kind of households is displayed in column with value zero. Total number of households not selling cheese is 235 out of 362 households, or about 65% of households (Fig. 23).



Count of Average Selling Price of cheese (BAM/kg)	Column Labels													
Row Labels	**0**	**4**	**5**	**5.5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**15**	**Grand Total**
Berkovići	10								13	1	2			26
Bileća	41				1									42
Čajniče	10		1		2				1					14
Foča	24	1				1				1	2	1		30
Istočni Mostar	2		2				1		4					9
Istočni Stari Grad	13		3			6	1	1	2					26
Kalinovik	6					2	3		6		5		1	23
Ljubinje	19							2	18		1			40
Nevesinje	15		1			1			7	1	5		1	31
Novo Goražde	7		2											9
Rogatica	22	2	1	1					1	1	1	1	1	31
Rudo	32	1	3											36
Trnovo	3		2		3									8
Višegrad	31		5						1					37
Grand Total	**235**	**4**	**20**	**1**	**6**	**10**	**5**	**3**	**53**	**4**	**16**	**2**	**3**	**362**

Figure 23: Distribution of houeholds by average price of cheese

5.9. Average of Total Yearly Household Income (BAM)

Total yearly household income per municipality is displayed on map in this example (Fig. 24). The basic column chart type is used to visualize the amounts incomes per municipalities.

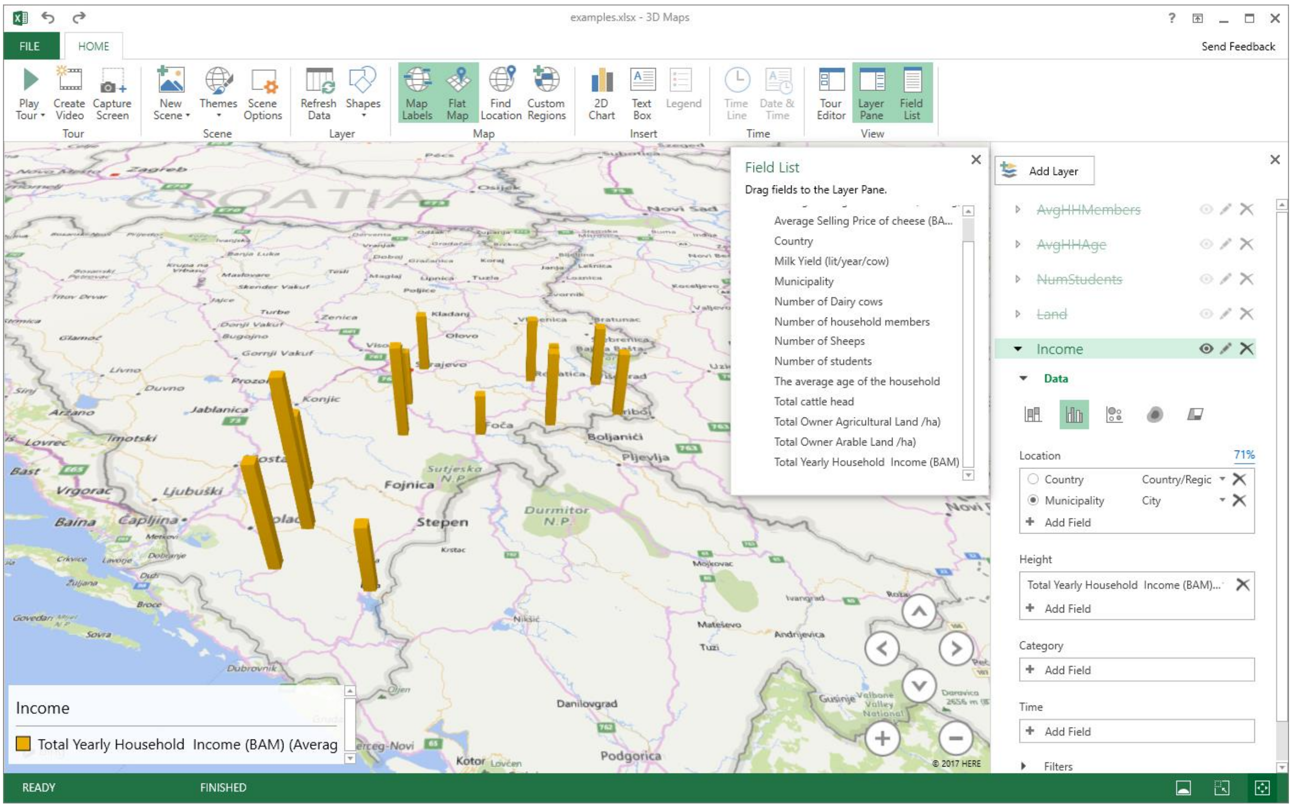


Figure 24: Average of total yearly household income

If we are interested in other data to combine and analyze with income, we could add more values for display on a map. In Fig. 25 it could be seen that the indicators of amounts of land are also displayed with income, but using different chart type. This could be useful to investigate if more income is comming from municipalities having more land. However, this is not the case as seen in Fig. 25, which could meen that the income is also coming from other kind of production (e.g. livestock).

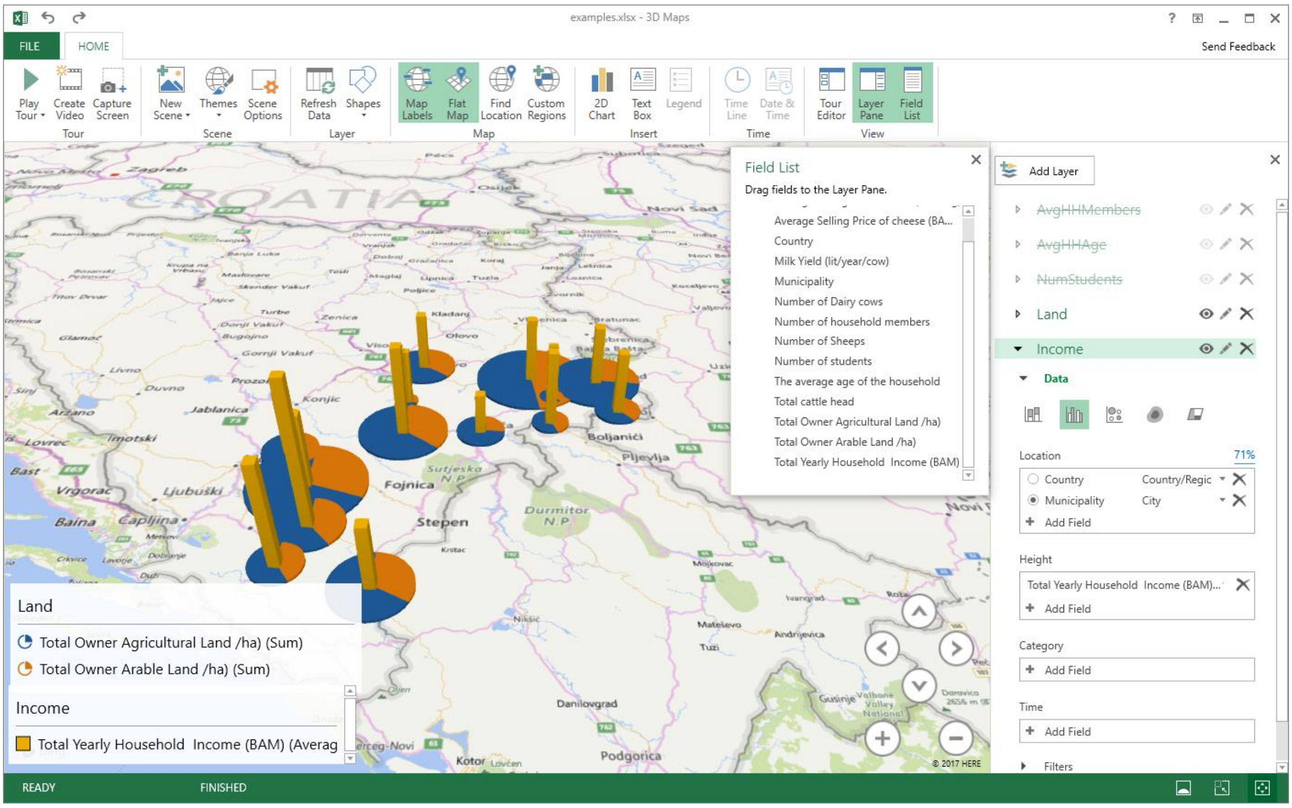


Figure 25: Average of total yearly household income combined with amounts of land

6. Conclusion

The application of modern IT tools is an every day need in today's business, regardless of the field and scope of work. For the success of the business, and especially for making key business decisions, it is essential to have access to accurate and timely information from all business processes. Modern technologies in the field of sensors, electronics and computing enable relatively inexpensive solutions to integrate data from all business processes and create conditions for efficient data analysis and reporting functions to support management. Agriculture is an area where the need for accurate and comprehensive data has always been present. Today's technology allows that the data are collected almost in real time, analyzed and made available to all interested parties. The application of technologies and tools that are presented in this course should enable modern managers and decision makers in agriculture to gain a better insight into the organization's performance through appropriate presentation and visualization of important business information, and also to make better decisions based on real data which should lead to business success.

7. References

Moskvins, G., Spakovica, E., & Moskvins, A. (2008). Development of Intelligent Technologies and Systems in Agriculture. In Proceedings of 7th International Conference Engineering for Rural Development: 108-113.

Sørensen, C. G., & Bochtis, D. D. (2010). Conceptual model of fleet management in agriculture. Biosystems Engineering, 105(1), 41-50.

Ghadiyali, T., Lad, K., & Patel, B. (2011, February). Agriculture intelligence: an emerging technology for farmer community. In Emerging Applications of Information Technology (EAIT), 2011 Second International Conference on (pp. 313-316). IEEE.

Tejas, G., & Kalpesh, L. (2015). Sustainable Decision Support System for Crop Cultivation. International Journal of Agricultural Science and Technology 3 (2): 36-45.

Ilie, I., & Gheorghe, G. I. (2016). Embedded Intelligent Adaptronic and Cyber-Adaptronic Systems in Organic Agriculture Concept for Improving Quality of Life. Acta Technica Corviniensis-Bulletin of Engineering, 9(3), 119-122.

Krintz, C., Wolski, R., Golubovic, N., Lampel, B., Kulkarni, V., Roberts, B., & Liu, B. (2016). SmartFarm: Improving agriculture sustainability using modern information technology. ACM SIGKDD DSFEW.

Celarc, S., & Gros, M. (2013). Calculation of the water balance and analysis of agriculture drought data using a Business Intelligence (BI) system. In GIL Jahrestagung (pp. 35-38).

Tyrychtr, J., Ulman, M., & Vostrovský, V. (2015). Evaluation of the state of the Business Intelligence among small Czech farms. Agricultural Economics, 61(2), 63-71.

Waga, D., & Rabah, K. (2014). Environmental conditions' big data management and cloud computing analytics for sustainable agriculture. World Journal of Computer Application and Technology, 2(3), 73-81.

Garg, R., & Aggarwal, H. (2016). Big Data Analytics Recommendation Solutions for Crop Disease using Hive and Hadoop Platform. Indian Journal of Science and Technology, 9(32).